Using ultrasonography as a teaching support tool in undergraduate medical education – time to reach a decision

Petru-Adrian Mircea, Radu Badea, Daniela Fodor, Anca Dana Buzoianu

“Iuliu Hatieganu” University of Medicine and Pharmacy, Cluj-Napoca, Romania

Abstract

Medical education and the process of teaching and learning, respectively, are constantly changing. This is induced by the pace at which knowledge, teaching methodology and its related tools are updated, the use of simulation, virtual depiction and the use of static and/or dynamic images. In this respect, X-ray images have been used in the understanding of macroanatomy ever since the beginning of the last century. Starting with the 1990s, when high-performing and relatively less costly equipment started to emerge, several experts in the field of education anticipated the huge resource that ultrasound could become in the field of medicine. The method is easy to understand, intuitive and available to anyone studying human anatomy and, subsequently, the major pathological issues during undergraduate medical studies. The present paper reviews the attempts made at using ultrasound as an educational support tool, from the first experiences in teaching anatomy (Hannover Medical School, 1996) until the recent development of an entire medical university curriculum integrating ultrasound (University of South Carolina, School of Medicine, 2006-2011). It is an exciting journey proving beyond any doubt that the method should be learned, understood and developed in medical schools from the undergraduate stage, together with the other clinical skills.

Keywords: ultrasonography, medical education, medical students

Introduction

Teaching and learning methodology are undergoing major changes related mainly to the way information is transmitted, stored, processed and used. Both educators and students are increasingly using visual systems, tridimensional images, simulation, schematic patterns and downloading often useless details, all of them based on computer processing. In medicine we witness deep changes, as the progress in molecular biology, genetics or immunology have opened the door to the understanding of previously impenetrable phenomena.

Among these changes, the recent advances in medical imaging have led to a new approach of many diseases, uncovering facts and data that could previously be known only by postmortem examination. On the other hand, in everyday practice, diagnosis is based on the same elements – patient history, physical examination, clinical reasoning, followed by investigations that are subsequently integrated into the clinical data; and for the physical examination we still use the same old instruments – the stethoscope, the ophthalmoscope and otoscope – part of the traditional physician’s black bag [1].

To all this, add the accelerated rhythm of the new information inflow in biomedical sciences, and the fact that all the “actors” (patients, health carers, and, not least, medical students) have increasing expectations, which prompt for major changes in the education of future physicians and medical specialists. This represents a real challenge for medical schools, as it requires changes in concept, structure and functions that must rapidly generate [2]:

- a new curriculum structure
• a new philosophy in which the traditional separation between basic and clinical sciences should be wiped out
• constant remodelling / adaptation of teaching methodology, from curriculum and syllabi to the tools used as support in the education process
• new teaching and learning ways and techniques
• new and innovative teaching support techniques, in a word – a new school of medicine. All the innovative changes that have been and will be imagined for the medical schools have a common goal – to achieve efficient and flexible medical education, perfectly adapted to current and future conditions, with the final result of forming doctors capable of the best service to their patients and communities.

A high number of studies and experiments have taken place in recent years, which document the increasing interest in using ultrasonography (US) as a support tool for teaching both at postgraduate (residents) and undergraduate levels. Starting from this premise, we considered it useful to review the experience of some medical schools, from the simple use of equipment visualising the insides of the body to the actual integration into the curriculum of ultrasonography as a working teaching method.

The discussion is ampler than a mere analysis of arguments for and against the introduction of US into medical education for undergraduate students. It touches on current aspects of curriculum structure and achievement of educational purposes. For a systematic approach, we proposed to present the cases related to US use in several domains: initial and continuing study of gross anatomy, study of the anatomy and function of abdominal organs, cardiovascular and musculoskeletal systems, teaching basic elements of physical examination and, finally, major abdominal and cardiovascular emergencies. And not least, we shall refer to the impact that US already has on some teaching concepts that have led to the reconsideration of curricula and syllabi in medical schools in the United States.

Ultrasound and gross anatomy

The old debate regarding the methods of studying anatomy, including the maintenance of cadaver dissection as a current method, is still going on. Plastination, computer and virtual models along with simulation have caused a lot of changes. However, recent studies have evidenced that the introduction of the new multimedia, interactive techniques have not limited the students favourable perception of the importance of dissection [3]. In other words, the students want to dissect, they feel dissection is useful for the understanding of anatomy and also that the time allocated is not sufficient [3]. At the same time, dissection itself may be performed differently, i.e. by using sectional images for a better understanding of topographical anatomy [4]. Nowadays we may therefore speak of a true virtual dissection, without a body!

And this is where ultrasonography intervenes. As compared to purely virtual dissection, the ultrasound technique allows the effective visualisation of most large anatomical structures, we may handle the transducer the way we handle the scalpel and the anatomical forceps. It’s as if using a magic scalpel, perfectly adapted to learning, and, above all, usable on a live body!

From this perspective, at least for the beginning of medical studies, the use of US by the student may be regarded as a method of “virtual dissection”, or, by a term already coined, as “living anatomy” [5]. Several pilot studies conducted in the last 15 years, some of them already entered in the current practice of the medical schools that promoted them, offer many arguments in favour of US as a valuable tool in the “live” study of anatomy.

The first attempts – revolutionary at the time – took place at the Faculty of Medicine of Hanover, with the first results published in 1996 [6]. Until that date the method had been used only sporadically, by cardiologists (echocardiography) and residency programmes [7].

In fact the inclusion of US in the study of anatomy in this medical school was a long process in time [5], whose promoters coined the term “living anatomy”. At the time the term referred to the integration of anatomical data (dissection) with those provided by radiology and the patients clinical data, from the perspective of clinical training. On this basis, ultrasonographic anatomy was gradually introduced into the curriculum of basic sciences [6]. Thus, first year students examined one another by ultrasound, in parallel with the study of the main organs and blood vessels of the abdomen. The results of the study were published in 1996 and they are very relevant: almost half of the students agreed that US helped them understand the topography of the abdomen and... they requested more US devices!

The same family of innovative methods also includes the study carried out in the Faculty of Medicine of Vienna in 2003 [8]. As the students were complaining that anatomy classes had no relation with practical real life, an experimental teaching module of the anatomy of the abdomen and pelvic organs was introduced, which included the simultaneous US visualisation of the same areas (1st – 6th years students). The results were spectacular: 93% of the students considered the course very important for their training, while 96% wanted similar courses, which made the faculty promote them further.
In the years that followed such experiences multiplied. Thus, in 2005 a group from McMaster University [9] introduced US in the study of anatomy and found a clear improvement of the students’ results and satisfaction. The experiment was viewed as a method of learning functional “live” anatomy, as certain anatomical structures – heart, vessels, bowels – move! The students greatly appreciated this method, considering it useful for both enhancing their clinical reasoning abilities and “exciting and engaging”.

With the same idea of “living anatomy” in mind, an Australian group [10] introduced a teaching module of dynamic cardiac anatomy in which they used real time 2D echocardiography, the images being projected “live” through an AV system. The images were analysed and discussed “face to face”. The undergraduate students from 3 schools – medicine, dentistry and science (biomedicine) – considered the method as innovative and useful as it offered “live” images and they wanted other body areas included in the teaching curriculum. Less enthusiastic were the conclusions of a study comparing the results of heart anatomy teaching on cadavers with ultrasound teaching [11]. In fact, the final conclusion is that both methods are equally efficient and that the future is held by their joint value.

A recent study included three focused ultrasound didactic sessions integrated into a Gross Anatomy curriculum [12]; 96% of the first year medical students appreciated that ultrasound-based teaching increased their knowledge of anatomy and would allow them to perform invasive procedures, the ultrasound integration into the curriculum being most welcome. The authors considered that the study provided important arguments in favour of US integration into the curriculum of medical schools.

**Ultrasound and basic clinical skills**

The skills and abilities acquired through the study of anatomy and physiology, including the use of imaging techniques such as US, are indispensable for the learning of the clinical examination. The relationship between the stark anatomical or even physiological elements may be naturally established by US, as proven by several studies investigating this aspect.

Thus, learning the clinical examination of the abdomen is generally perceived as difficult by the students. The association of the visualization of abdominal organs by US, even with a minimal training, improves the technique of physical examination after the students have acquired skills with basic examination manoeuvres” [13].

The idea that an introductory course in ultrasonography may help the students understand and learn correctly the basic skills of physical examination becomes more and more obvious. In this respect, recent studies have suggested that portable US devices should be mandatory in the equipment used by general practitioners, internists, geriatric specialists or emergency units [1,14-16]. The benefits for the patient are above question, regarding the diagnostic accuracy and speed at the patient’s bedside. This leads to the rational conclusion that minimal training in ultrasonography should be included at the undergraduate level of education, subsequently to be developed during specialized courses and/or residency.

**Ultrasound and cardiology / cardiac semiology education**

Many studies regarding the use of US as a didactic tool focused on the heart and vessels, especially due to the advent of hand-carried ultrasound devices. This makes the technique to be considered as a natural extension of the physical examination by stethoscope, which helps develop clinical reasoning skills [17].

Cardiologists were actually the first to perceive the exceptional availability of echo(cardio)graphy as the ideal instrument to complete the physical examination [18]. For the patient with cardiovascular disease the best approach at the first examination would be to combine the clinical examination with modern technology [19]. Moreover, starting from the same advantages of miniature portables devices providing excellent images, it is stated that “it is conceivable that the hand-carried echocardiographic devices will be used in medical school curriculum to enhance medical student education in the future” [19].

The same group [20] tested the use of handheld devices by 4th year medical students and clearly demonstrated that this is possible and even leads to increased bedside diagnosis accuracy. On the other hand, this study together with another one including internal medicine residents certified that young trainees learned very fast the simple echocardiography elements [21], which is another argument in favour of the method.

Even further, a study comparing diagnostic accuracy using hand-carried units (HCU) by undergraduate students with that of cardiologists using standard diagnostic methods (auscultation) showed that students identified correctly 78% of the true pathological elements, while cardiologists only identified 49%. Overall, “the diagnostic accuracy of medical students using an HCU device after brief echocardiographic training to detect valvular disease, left ventricular dysfunction, enlargement, and hypertrophy was superior to that of experienced cardiologists performing cardiac physical examinations” [22].
Ultrasound and teaching the musculoskeletal system

It is well known that a large proportion of rheumatologists nowadays use the US technique (MUS) for the noninvasive diagnosis of musculoskeletal disease and for US guiding of therapeutic procedures. This has led to the preoccupation for the specialized training of residents, because “training in MUS must be an integral part of the curriculum for rheumatology” [23].

The same group that published data on the introduction of US in the study of live anatomy of the abdomen and blood vessels in 2005, also introduced US in the study of musculoskeletal anatomy [24]. The conclusion was that the introduction of hands-on sessions facilitated the learning of musculoskeletal anatomy elements and helped the students acquire the skills of the clinical examination of this system.

Tackling the problem of students in later years that study rheumatology, another study concluded that US contributed to a higher quality of their education and was associated with an extremely positive feedback, the method being ideal for supporting education in rheumatology [25].

Ultrasound and emergency medicine

One of the current approaches of using US in medical education started from the exceptional value of the technique in emergency conditions. This led to the development of a concept – to offer medical students from the very first years a learning tool that “extends” clinical examination [26].

Simple techniques such as FAST are easy to understand and learn by the students, who like this approach. All the lessons learnt from emergency medicine plead for the necessity to reconsider the curricula of medical schools and must be taken into account by all those responsible for undergraduate curriculum design. A recent British study clearly affirms: “Medical schools need to consider the formal introduction of ultrasound teaching in their curricula to equip future doctors with relevant skill sets” [27].

The same conclusions were reached by another study initiated by an emergency service, which demonstrated that undergraduate students may be easily trained to recognize and examine the abdominal aorta. Starting from this finding the authors remark: “It is time for the medical education community to address whether focused ultrasound training should accompany traditional clinical skills, such as using a stethoscope, in UK medical school curricula” [28].

How fast can basic ultrasonography skills be acquired?

A common aspect of all the studies investigating the utility of introducing US as a support tool for medical education is the evidence of a rapid learning curve of the basic technique. US images may be quickly understood, even with minimal theoretical elements offered to the students [29,30].

Students accept the method enthusiastically, the great majority wanting to continue using it and perfect their skills in handling the equipment, being able to increase their proficiency in acquiring quality images [31]. It is obvious that students are aware of the fact that this method will help them in the future, even if further assessments are still necessary and US has not been incorporated into the curriculum of all the specialties [32].

Ultrasound makes its way into the curriculum of medical schools

As already mentioned, the progress made in using US as a didactic support tool in the beginning of medical training and its rational integration of this initial training with the clinical one created new concepts. The consolidation of these concepts along with the innovative spirit of educators has made a number of medical schools develop new curricula that integrate US in all the years of study, using its exceptional qualities for the training of medical undergraduates.

Thus, in 2008 the first description of such a pilot curriculum was published [33] by the Faculty of Medicine of Wayne State University, Detroit, Michigan. The decision was justified by the fact that the residency training programs had adopted US training, and therefore medical schools had to take into consideration the integration of US in their own curricula. US integration was both in basic sciences and clinical sciences, being achieved through 6 organ – modules: Introduction to Ultrasound, Musculoskeletal Ultrasound, Vascular and Cardiac Ultrasound, Ultrasound of the Abdomen, Genitourinary Ultrasound si Ultrasound and Procedural Skills.

Preliminary results were encouraging: 83% of the students gave a positive account of their experience, and 91% stated that carrying on the US training would be beneficial for the next 4 years of medical school. The school is optimistic regarding the future and considers that the development of precise portable devices will change medical practice, from rural to spatial medicine, therefore the new generation of doctors should be able to make use of the progress.
Probably the most relevant experience and the most consistent results of US integration into a medical school curriculum belong to the Medical School of South Carolina University [34]. Here a curriculum integrating US was devised, designed and put into practice for the all 4 years of basic and clinical education. The curriculum has a modular structure, and the US modules are integrated in every stage of the learning process. Logically, it started with the use of US in the gross anatomy study, then in the physiology of cardiovascular hemodynamics, at the same time with its introduction into clinical medicine, going through the physical examination, pathophysiology and disease. US is not intended to replace good examination skills, but rather help develop these skills. The application of the integrated curriculum compelled the school to rethink the way medical education takes place as a whole, choose to work with smaller groups and precise timing, though sufficiently flexible, have constant feedback from the students, develop specific teaching material, improve the knowledge and skills level training of the faculty, develop resources. In the school opinion, the innovative component of the curriculum is not useful just for a modern student education, but it is also attractive for the young, which provides a wider selection basis for the school.

Numerous arguments are in favour of the solution chosen by this medical school. It is certain that students like to work this way and their training will contribute to the increase of the health care and safety given to the patients. It is also certain that such programs will be developed by other schools as well.

There are limits to all of this, of course, related to the material resources necessary (equipment), and especially human resources trained in ultrasonography, which are far from available in all schools of medicine [35].

However, we must quote the authors who imposed a new concept in the medical schools: “Medical education in the next decade will likely undergo a true paradigm shift based on the application of ultrasound technology. This shift will fundamentally change how medicine is taught and practice” [34].

As physicians and educators, we are on the threshold of a new phase in time. We have discovered a method that has been at hand for a long time, but which has been made readily available and widely usable due to technical progress. Nowadays we have a complex magic stethoscope that we should cherish in order to re-learn what we learnt ourselves a long time ago, to teach the young ones medicine that is useful and dedicated to our patients.

In this spirit, below are listed 10 reasons why ultrasonography should be always the choice as an ideal support tool in medical education.

10 reasons for introducing ultrasonography as a method into the medical education curriculum

1. Easy to explain – for the understanding of physical principles
2. Easy to understand regarding the basic clinical signs of disease
3. No difficulty for the student to learn or achieve significant images (rapid learning curve)
4. Allows the natural connection between “what you look for and what you see”
5. Provides live anatomy (moving), therefore it stimulates thinking as every movement of the transducer means another section/relatiopn between the structures visualized
6. Non-traumatic – non-invasive, reproducible, repeatable
7. Relatively inexpensive, increasingly accessible!
8. Becoming extremely portable! High quality images may be obtained nowadays with small devices!
9. User friendly, creates a feeling of actual participation in the diagnostic process and coming closer to clinical medicine (for the students in the first years)
10. Raises enthusiasm, fascinates, and is a lot of fun!

**Conflict of interest:** none

**References**